

# Atmospheric Effects on Propagation of Highway Noise Arizona DOT

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*acoustics, transportation + strategy*

# Program Components

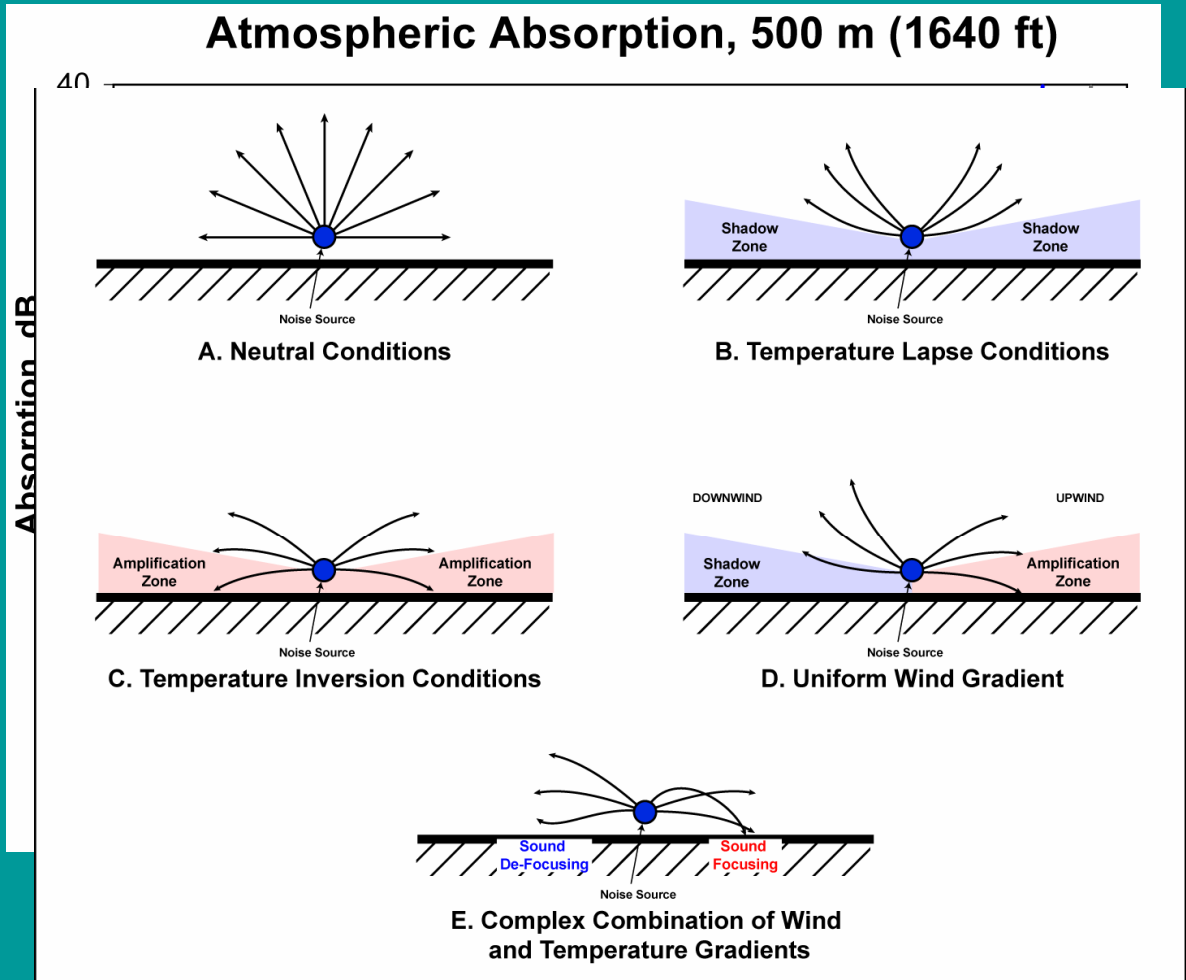
- Literature Review
  - Meteorology
  - Atmospheric effects on sound propagation
  - Modeling approaches
- Measurements
  - Detailed measurements for two weeks in March
  - Supplementary measurements in October after ARFC installed
- Computer Modeling
- Conclusions

# Meteorological Conditions in Phoenix Area

- Light winds, clear skies, weak synoptic flow 70% of the time
- Temperature lapse (upward refraction) during daytime and temperature inversion (downward refraction) at night
- Up-slope airflow during the daytime and down-slope flow at night

# Atmospheric Effects

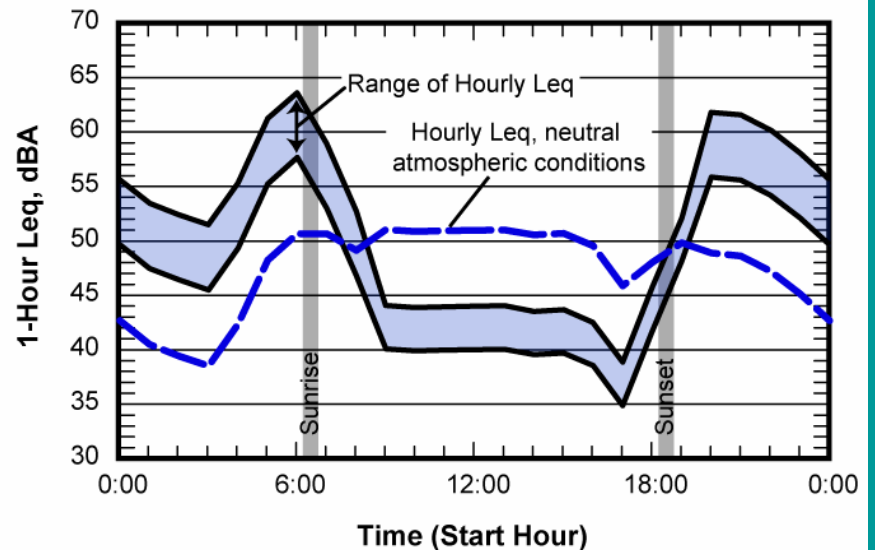
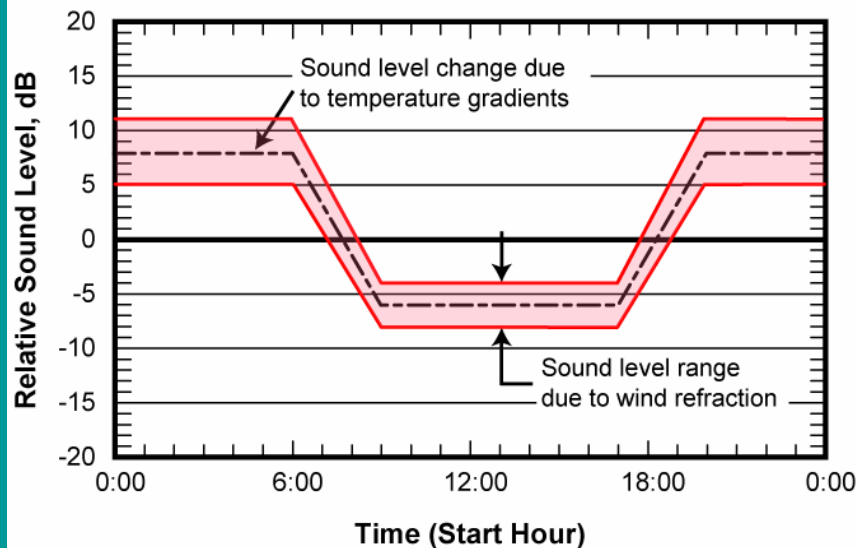
- Absorption
- Turbulence
- Refraction



# Typical Diurnal Variation (400+ m from freeway)

DOWNWIND for Early Morning Down-Slope Flow

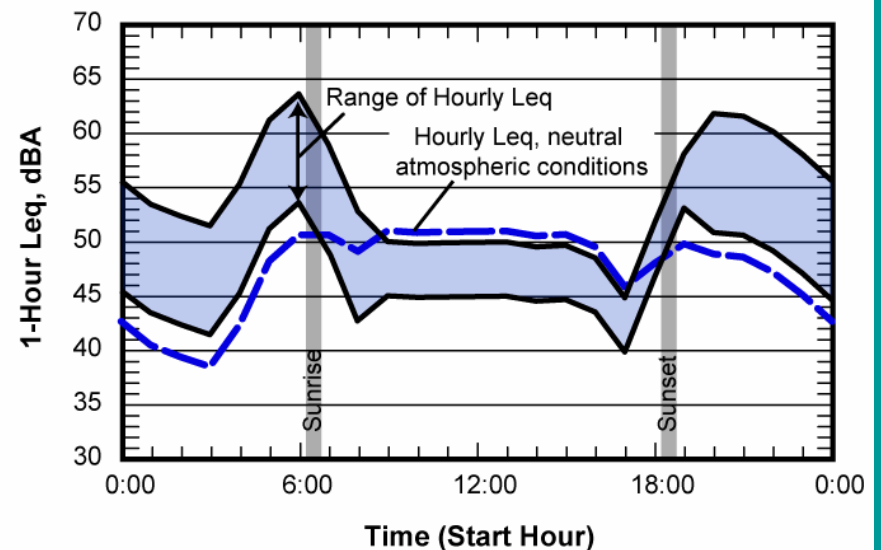
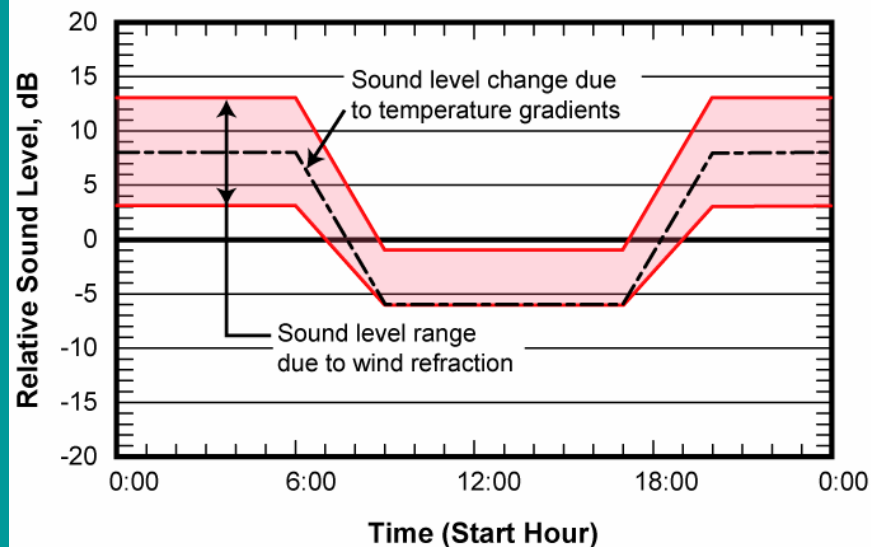
UPWIND under Daytime Up-Slope Flow



# Typical Diurnal Variation (400+ m from freeway)

UPWIND for Early Morning Down-Slope Flow

DOWNWIND under Daytime Up-Slope Flow



# Measurement Program

- Detailed noise and meteorological measurements
  - 1-sec Leq, 1/3 octave band, continuous recording, 45 ft met tower...
- Four long-term sites plus short-term measurements to fill in gaps
- Two weeks in March, one week in October 2004
  - Before and after installation of ARFC to reduce noise





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Field test area

N



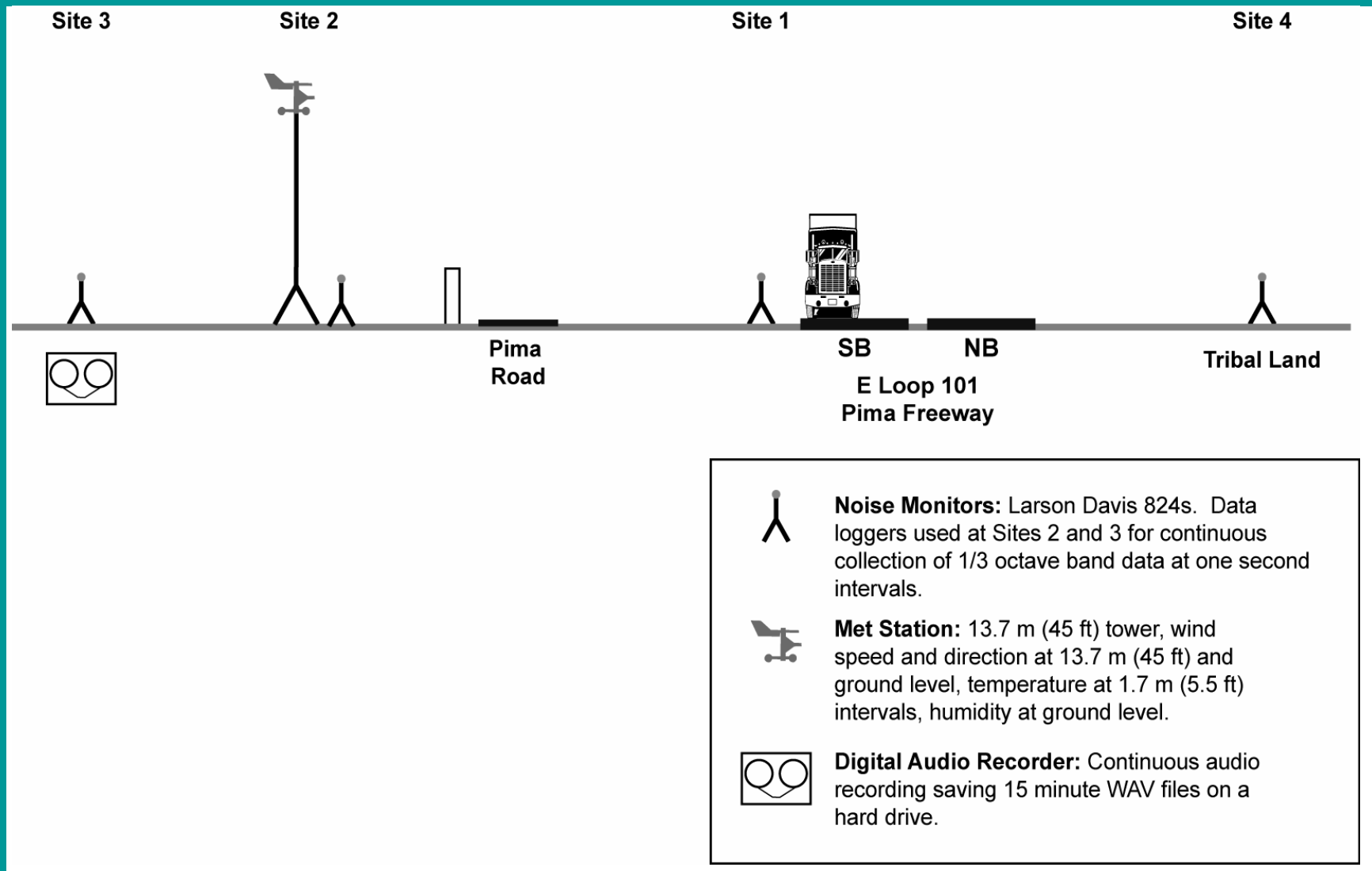




Image © 2005 EarthSat  
Image © 2005 DigitalGlobe

© 2005  
Goo

# Schematic of Field Equipment





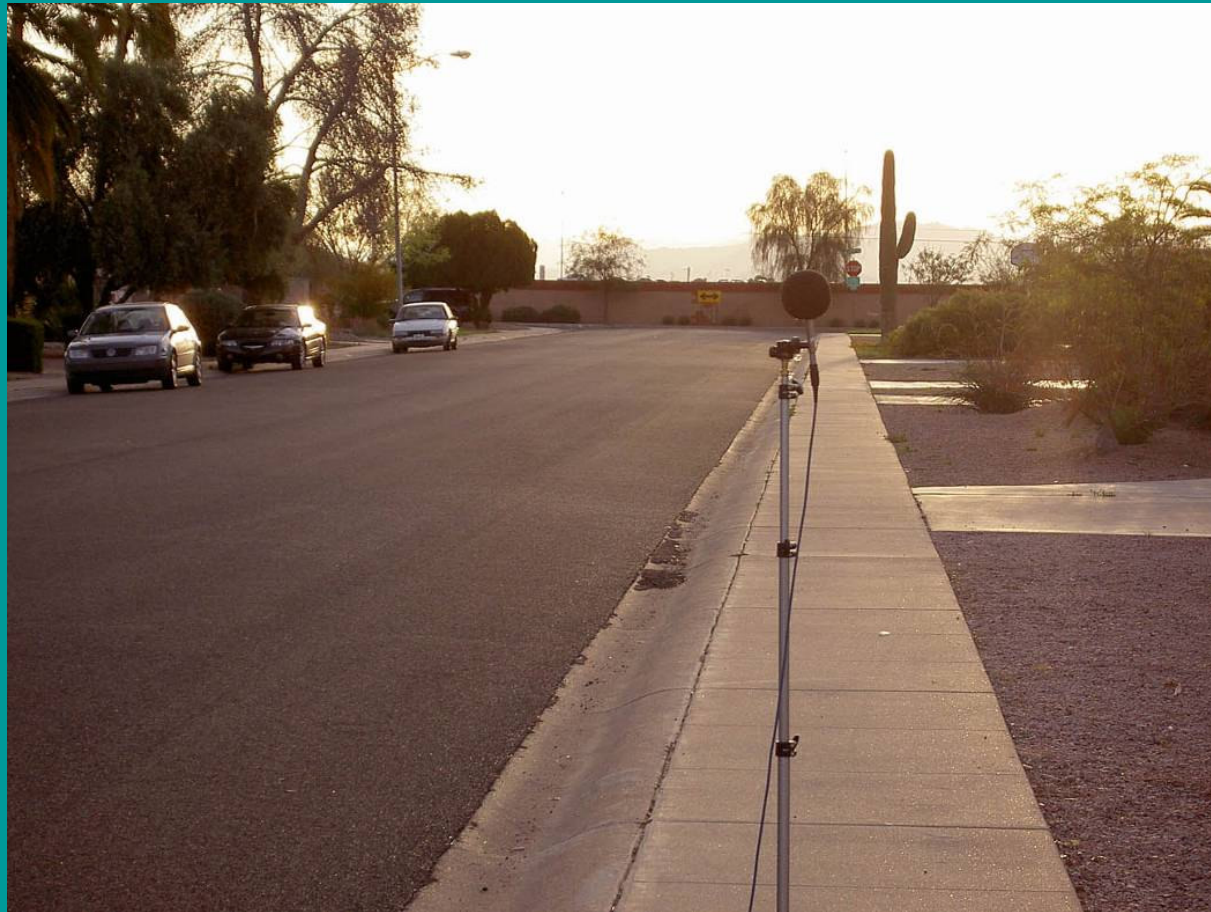
# Site 1



# Site 2 Met Tower

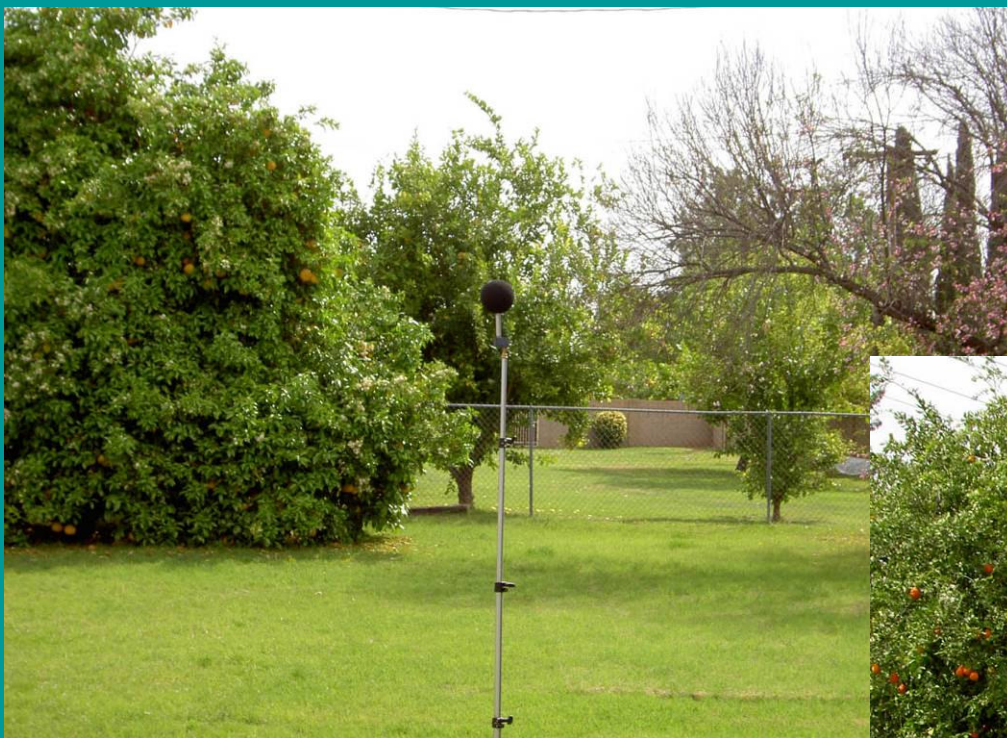


# Site 2, Front Yard





# Site 3

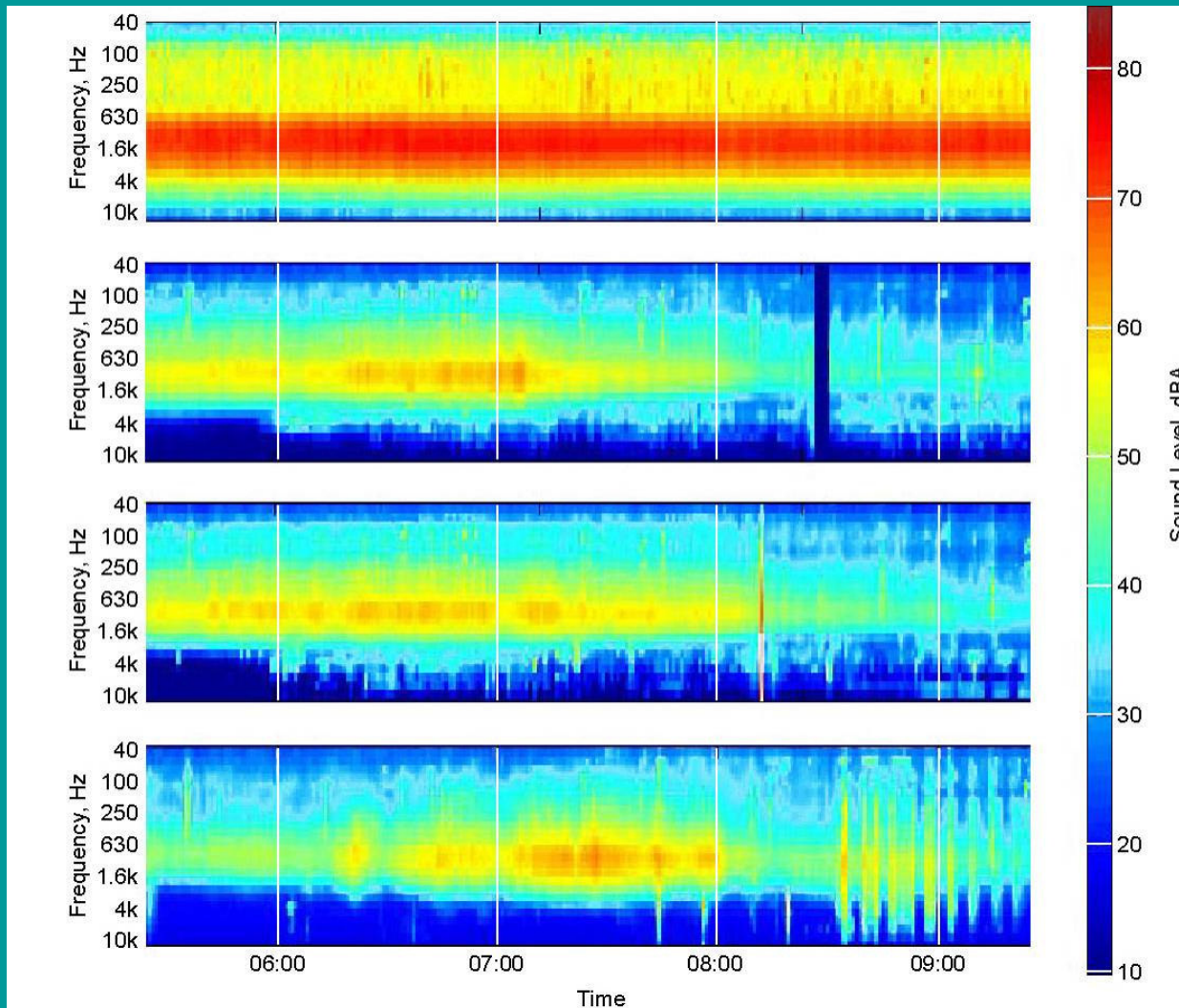




# Site 4 (Tribal Land)

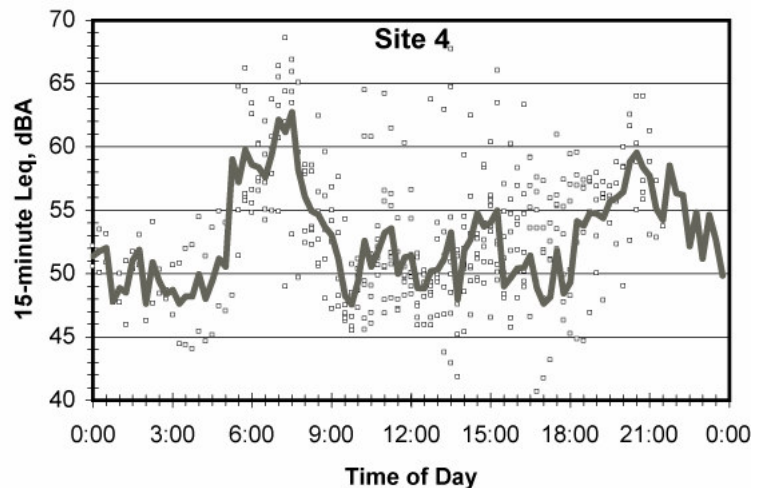
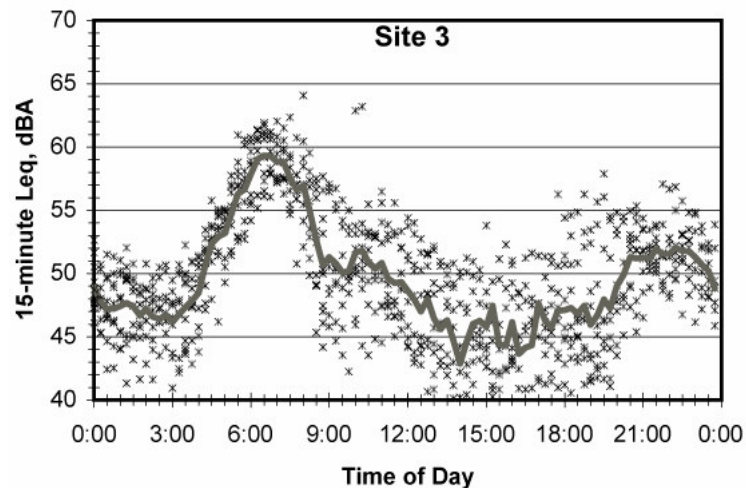
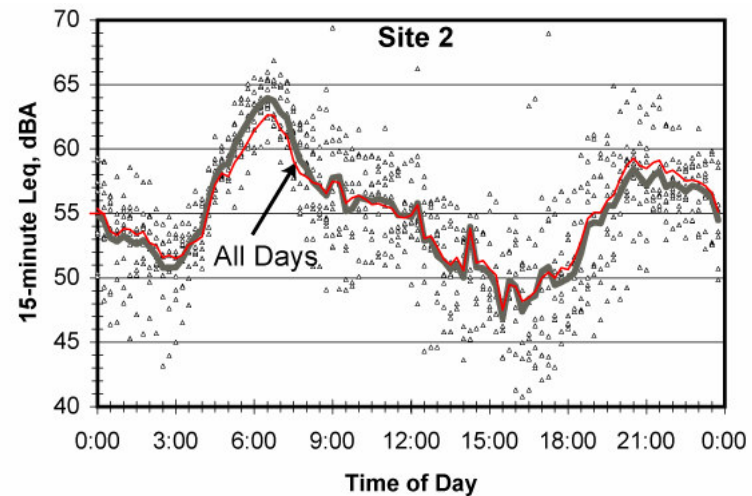
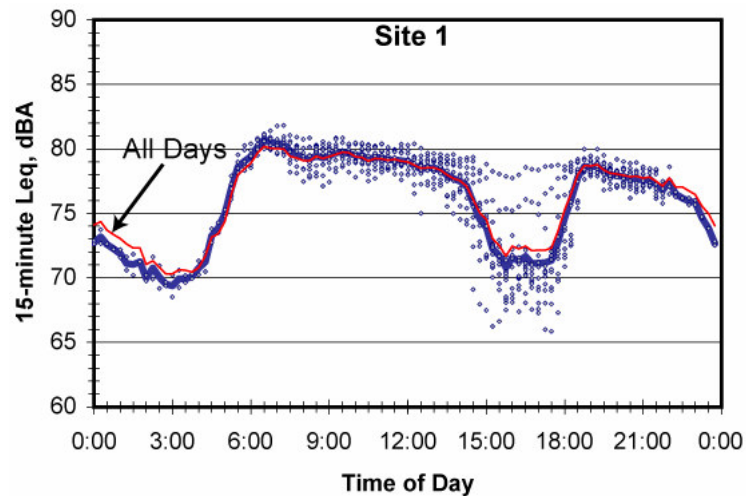


# Spectrogram, March 18, 2004, 5:30 to 9:15 AM

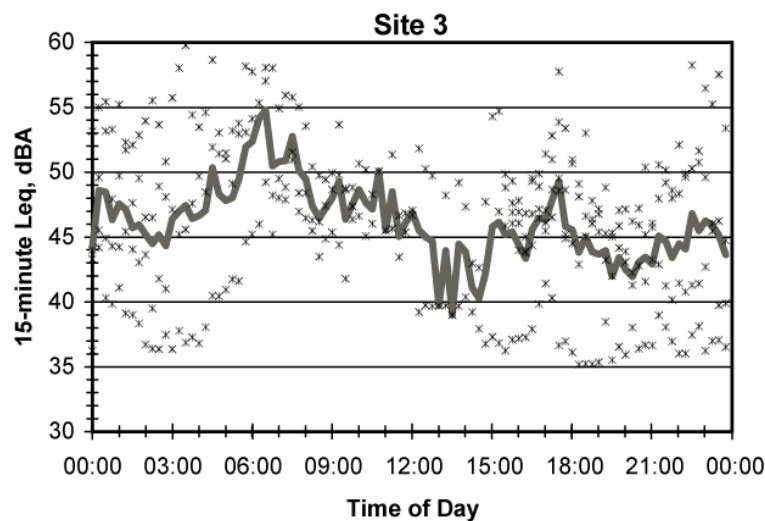
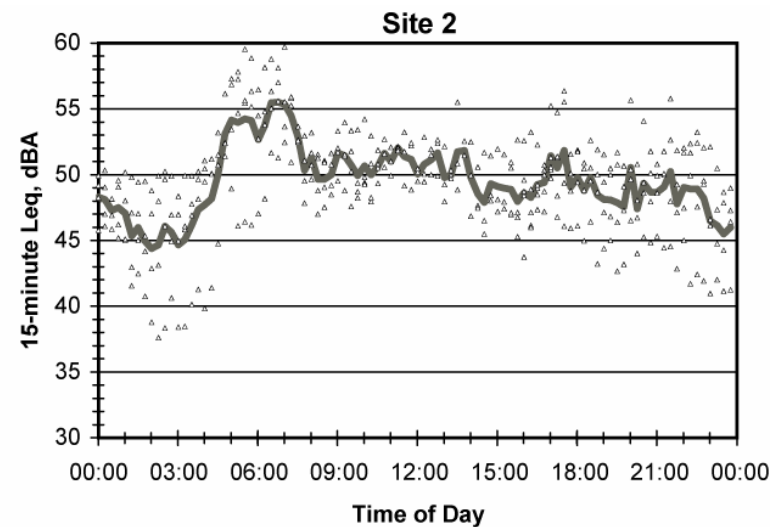
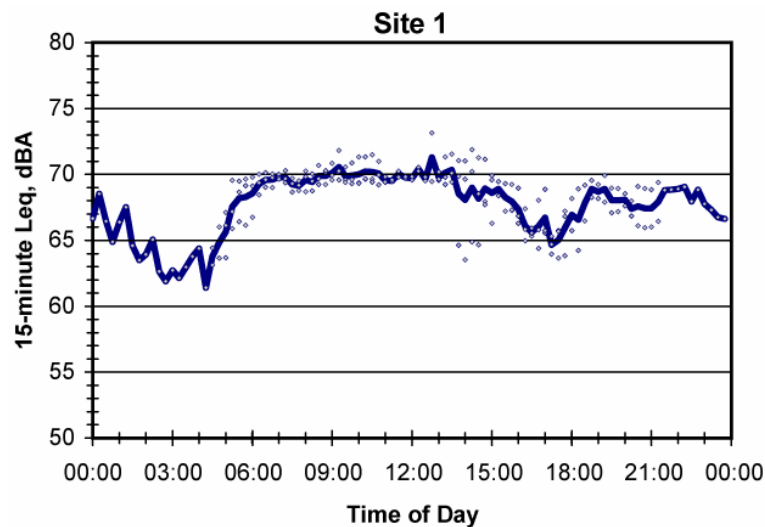




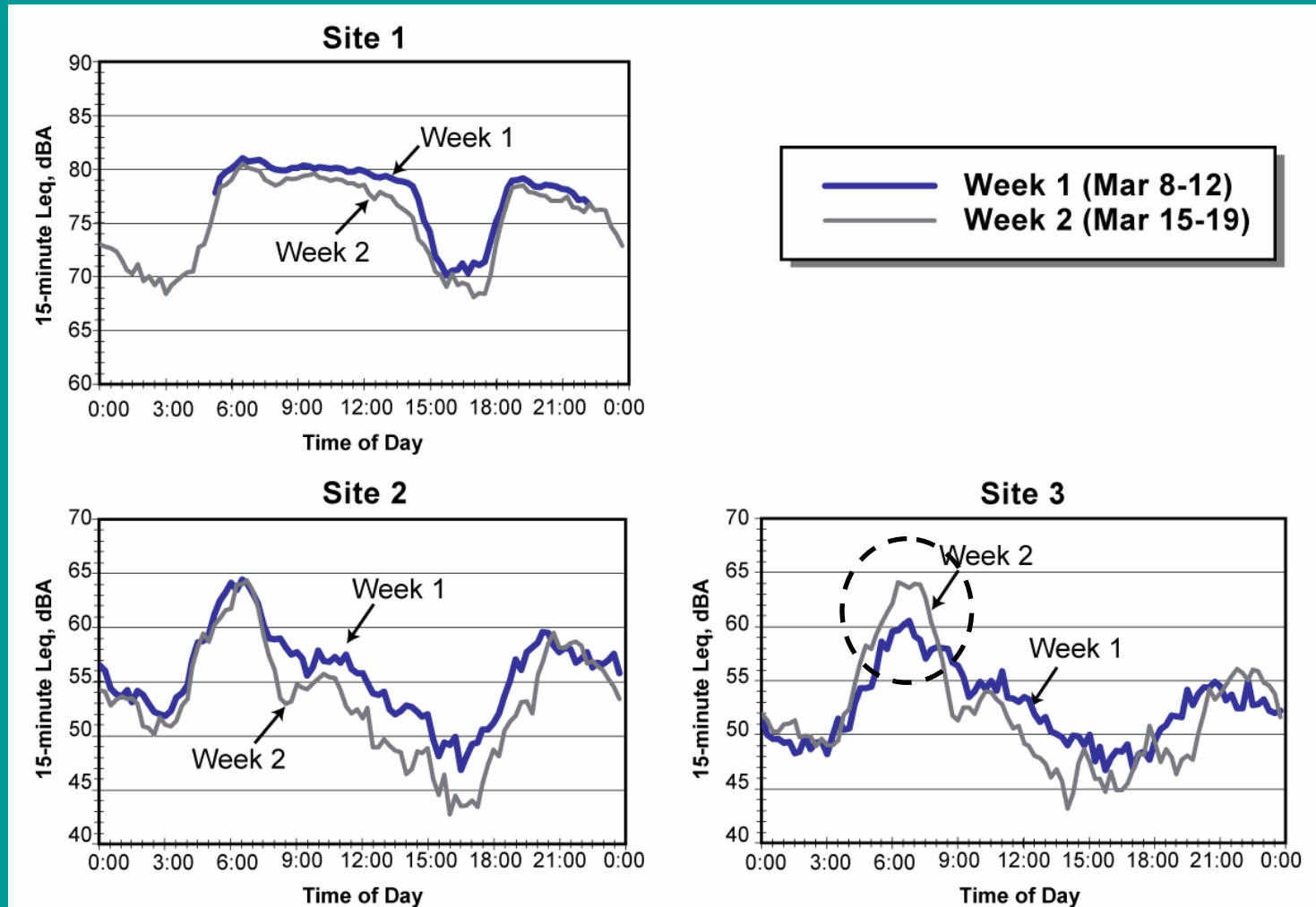
# 15-Minute Leq, All Weekdays, March 2004



# 15-Minute Leq, All Days, October 2004

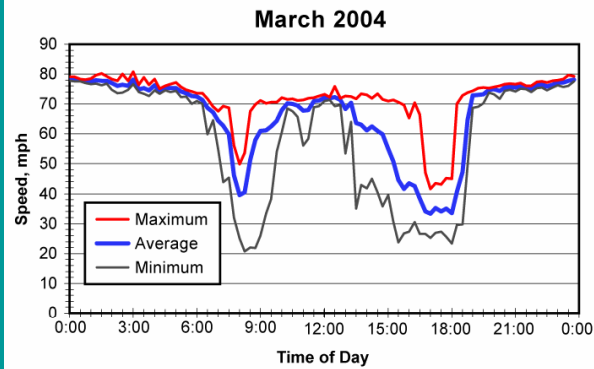


# Comparison of 1<sup>st</sup> & 2<sup>nd</sup> Week, March 2004

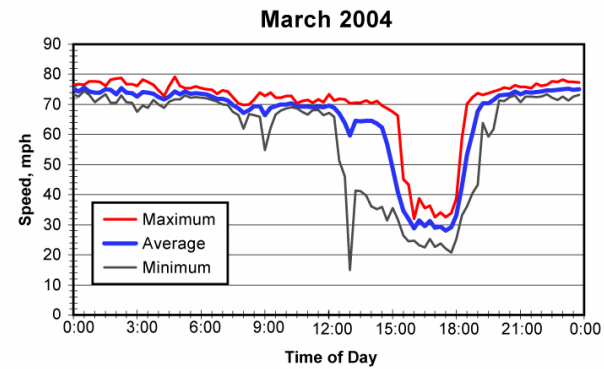


## Average Speeds, Weekdays

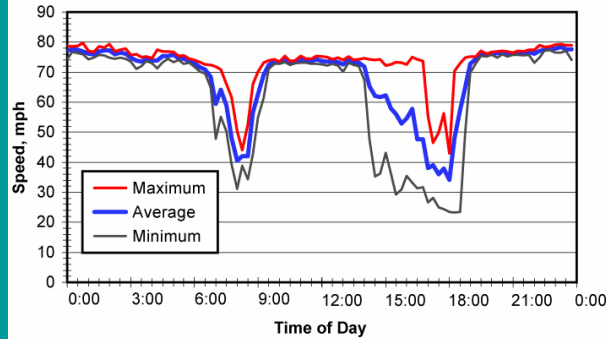
### NORTHBOUND



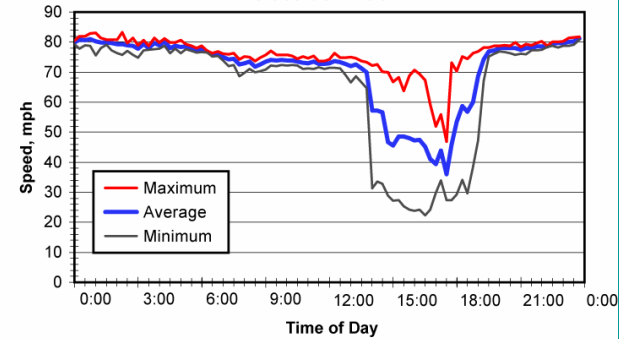
### SOUTHBOUND



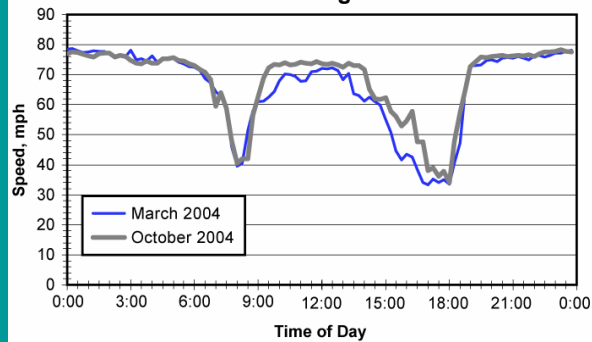
### October 2004



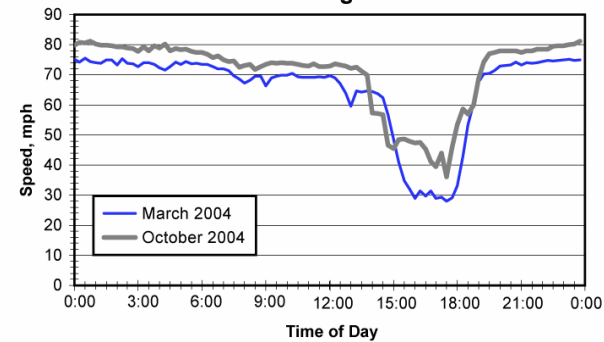
### October 2004



### Averages

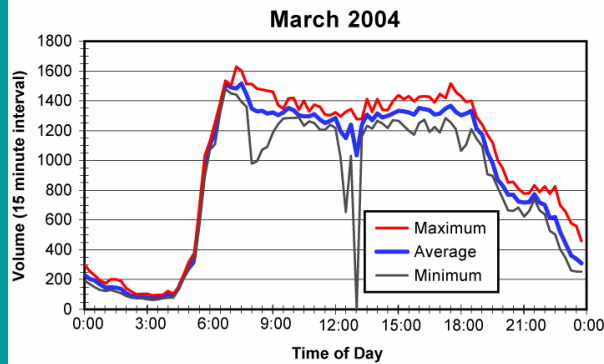


### Averages

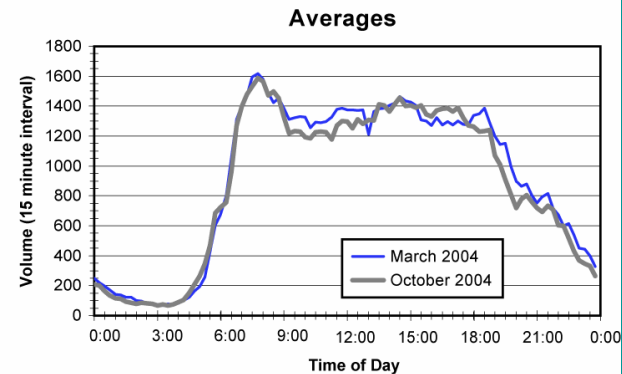
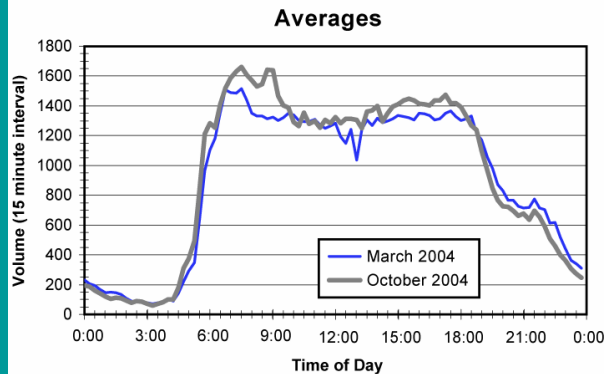
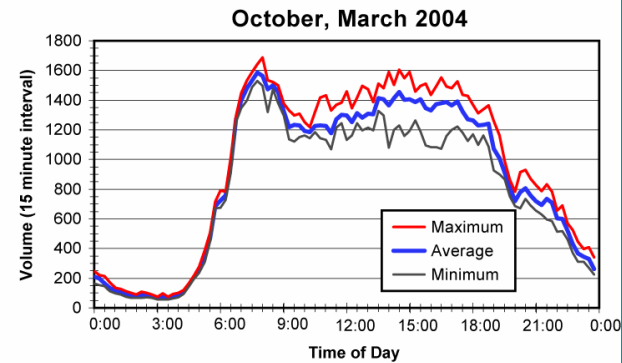
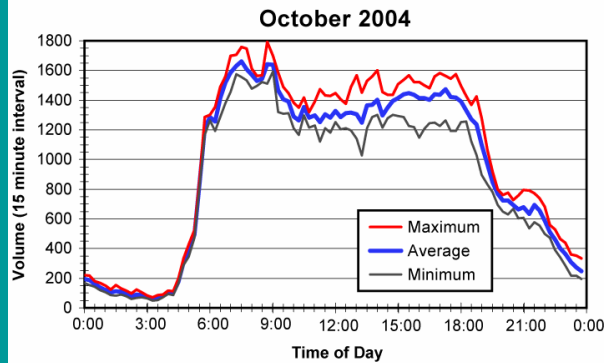
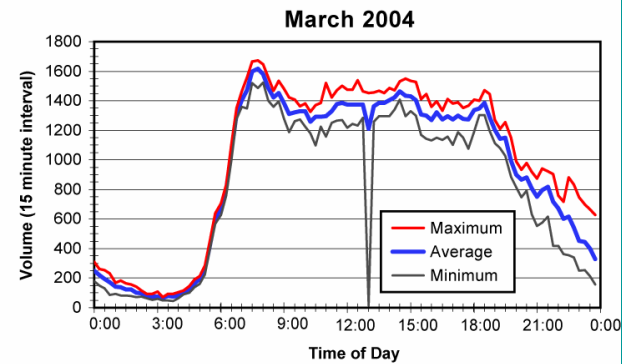


## Average Weekday Traffic Volumes

### NORTHBOUND

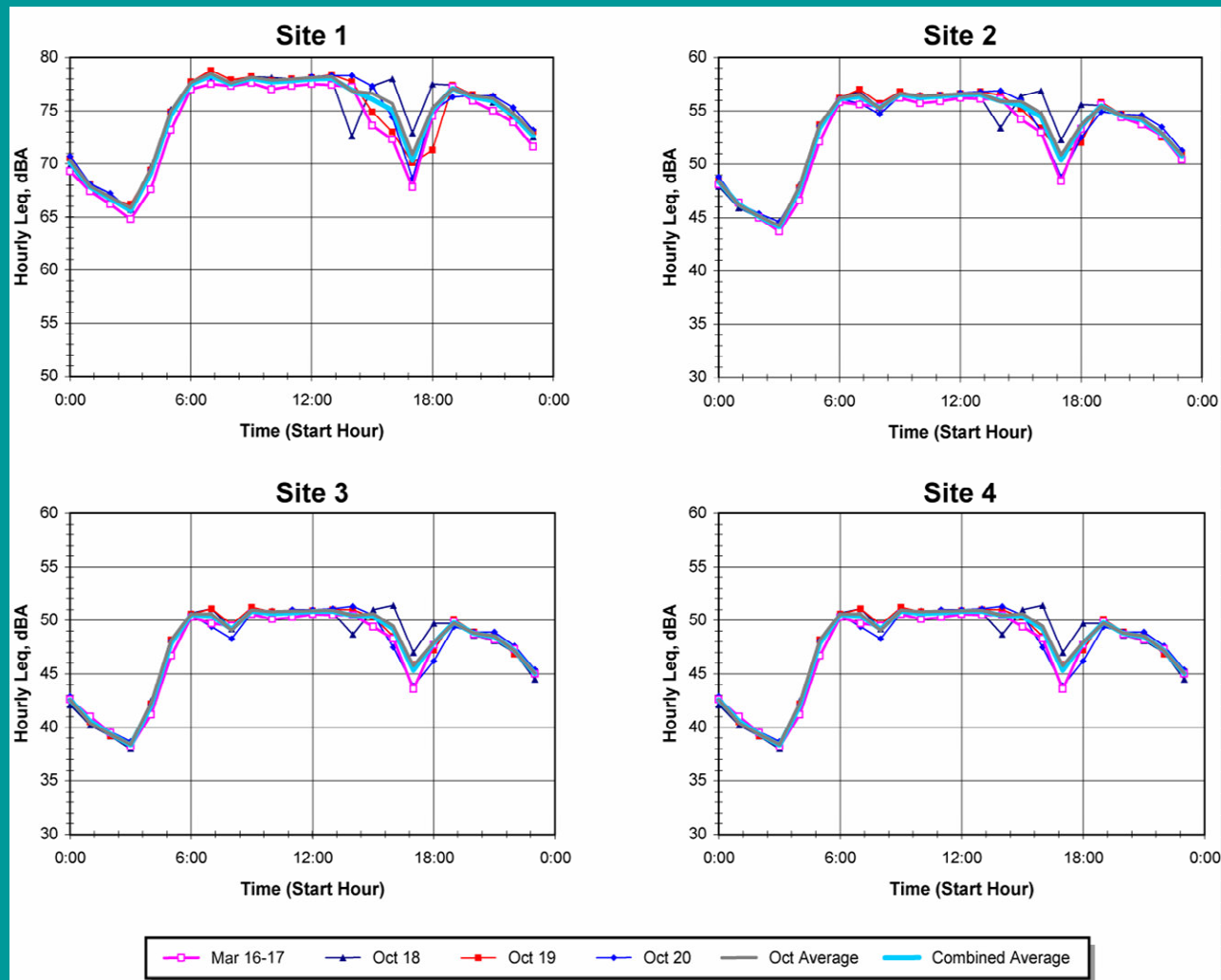


### SOUTHBOUND



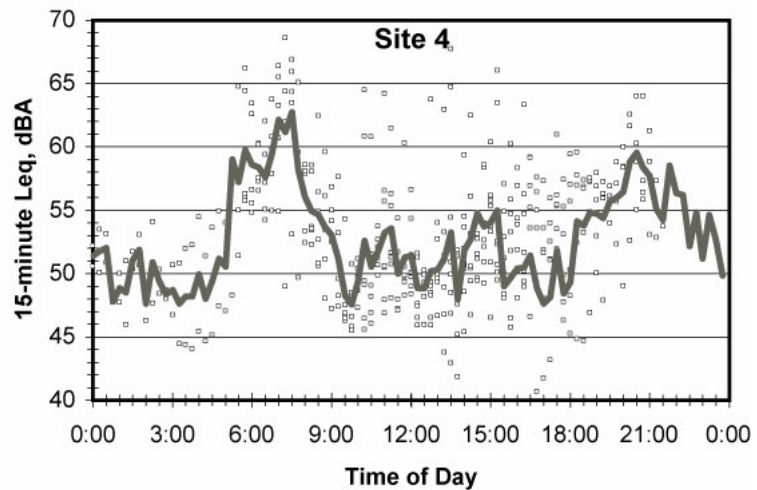
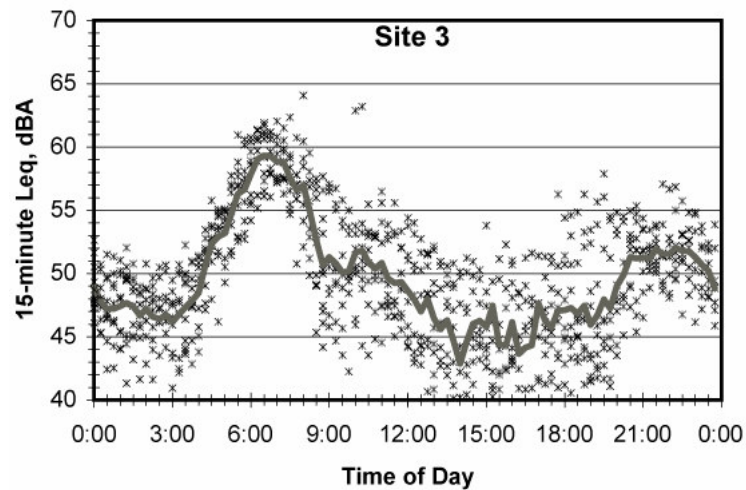
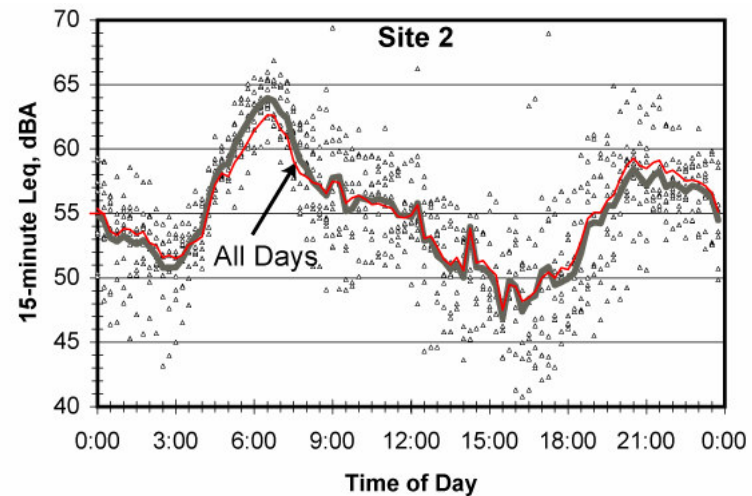
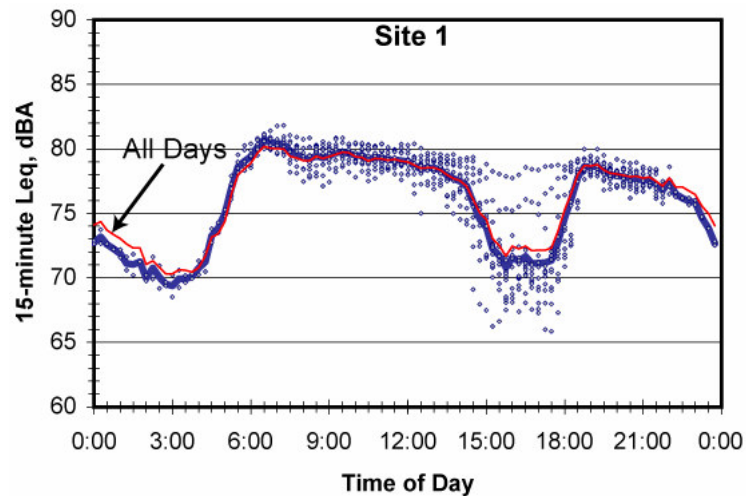
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# Sound Levels Predicted Using TNM (No Atmospheric Effects)

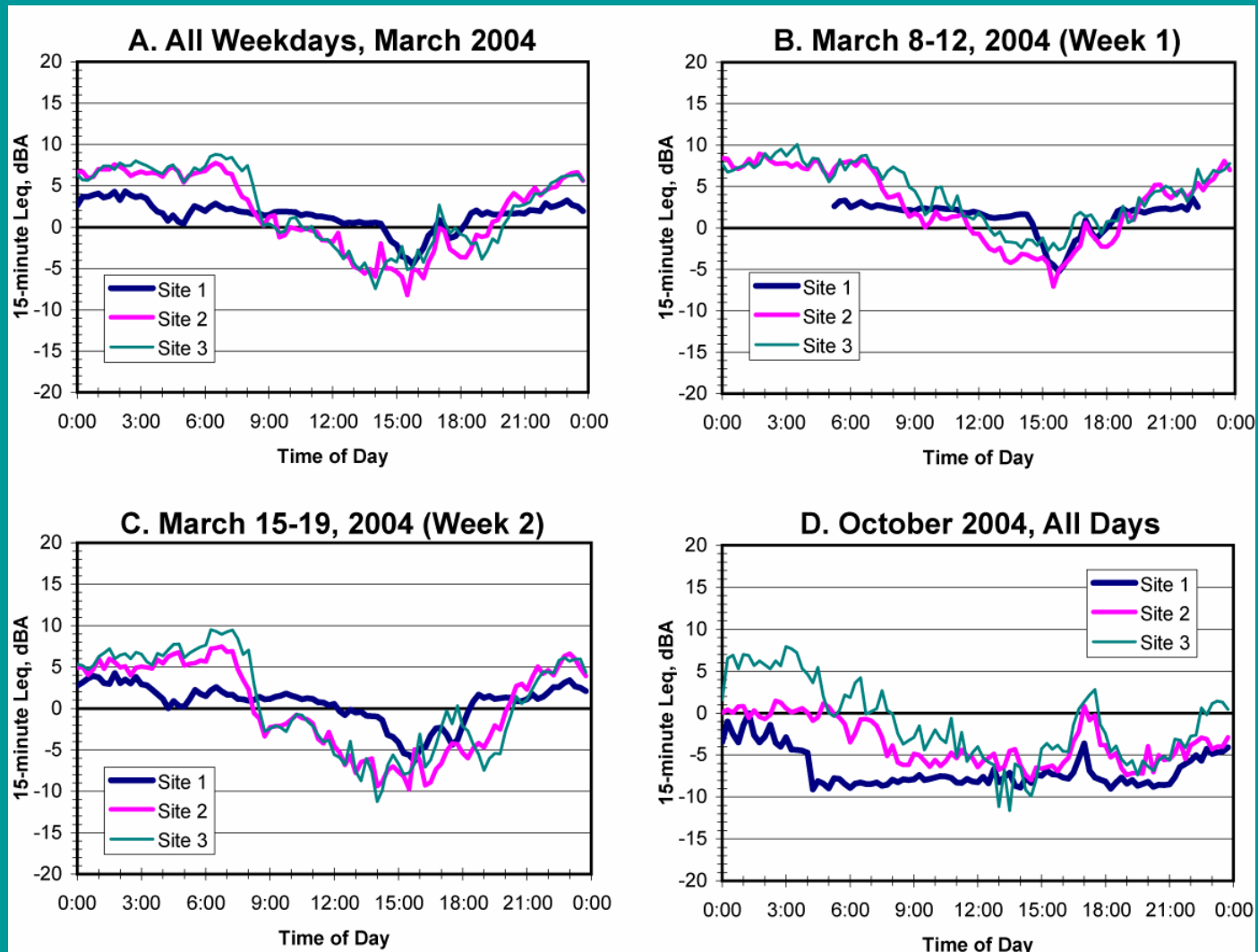




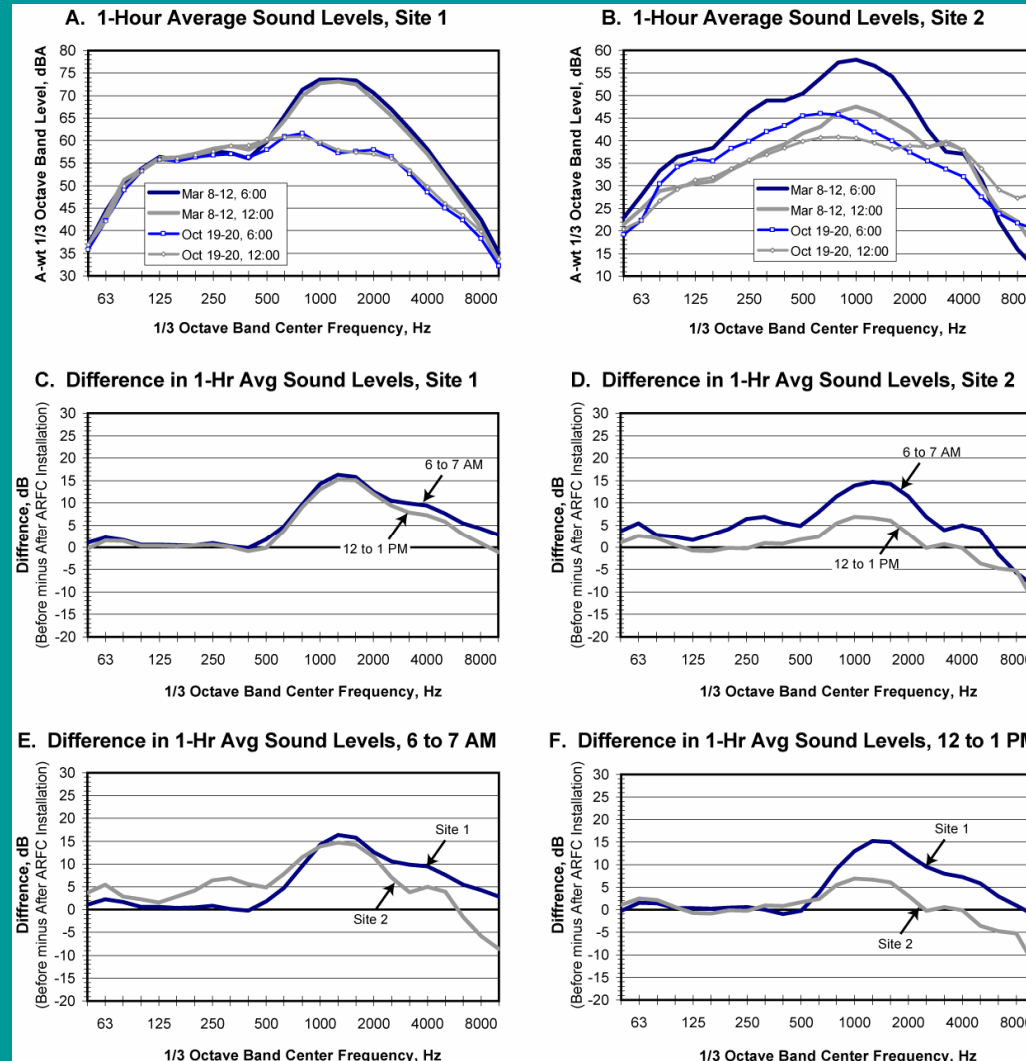
# 15-Minute Leq, All Weekdays, March 2004



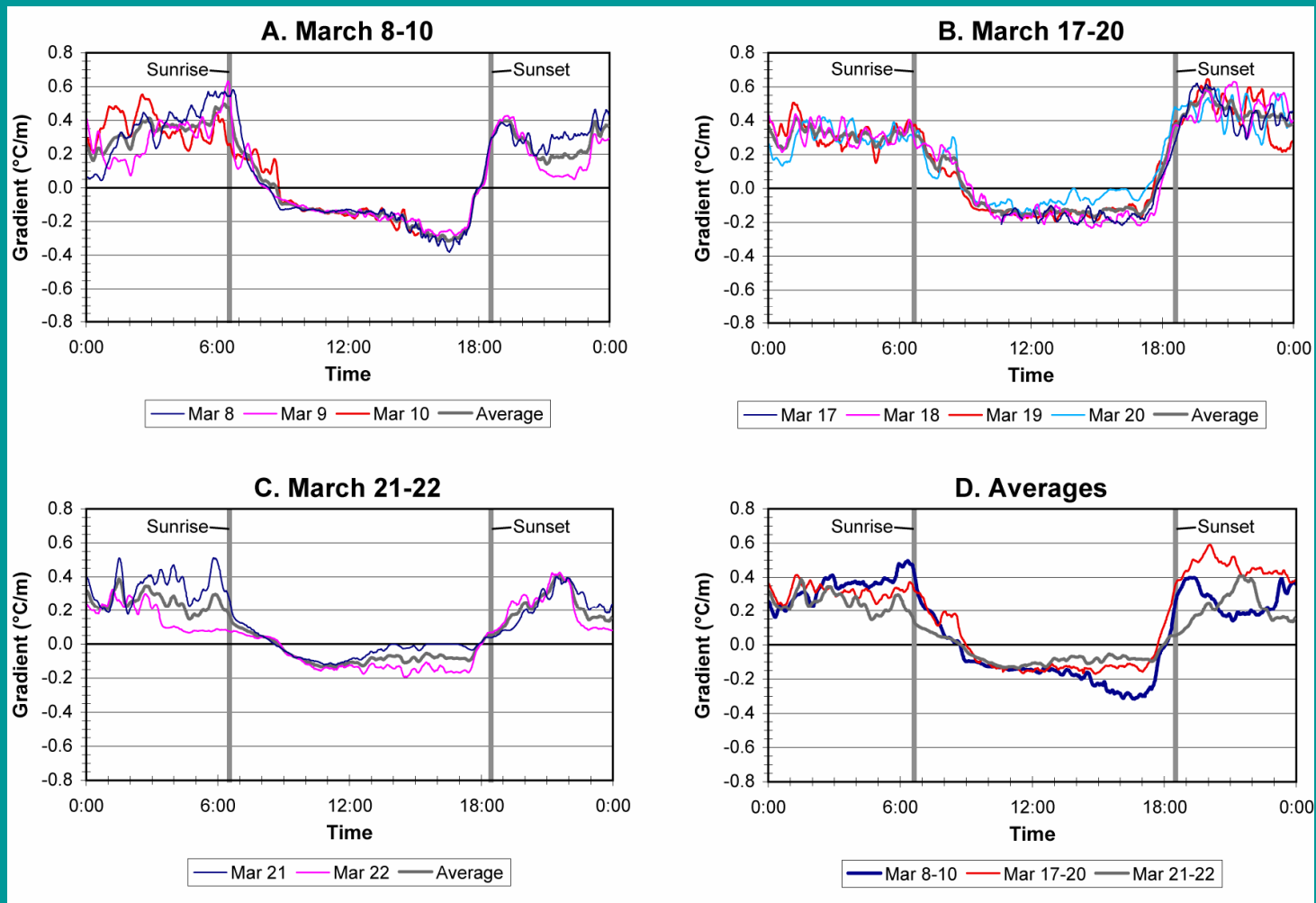
# TNM Normalized Sound Levels



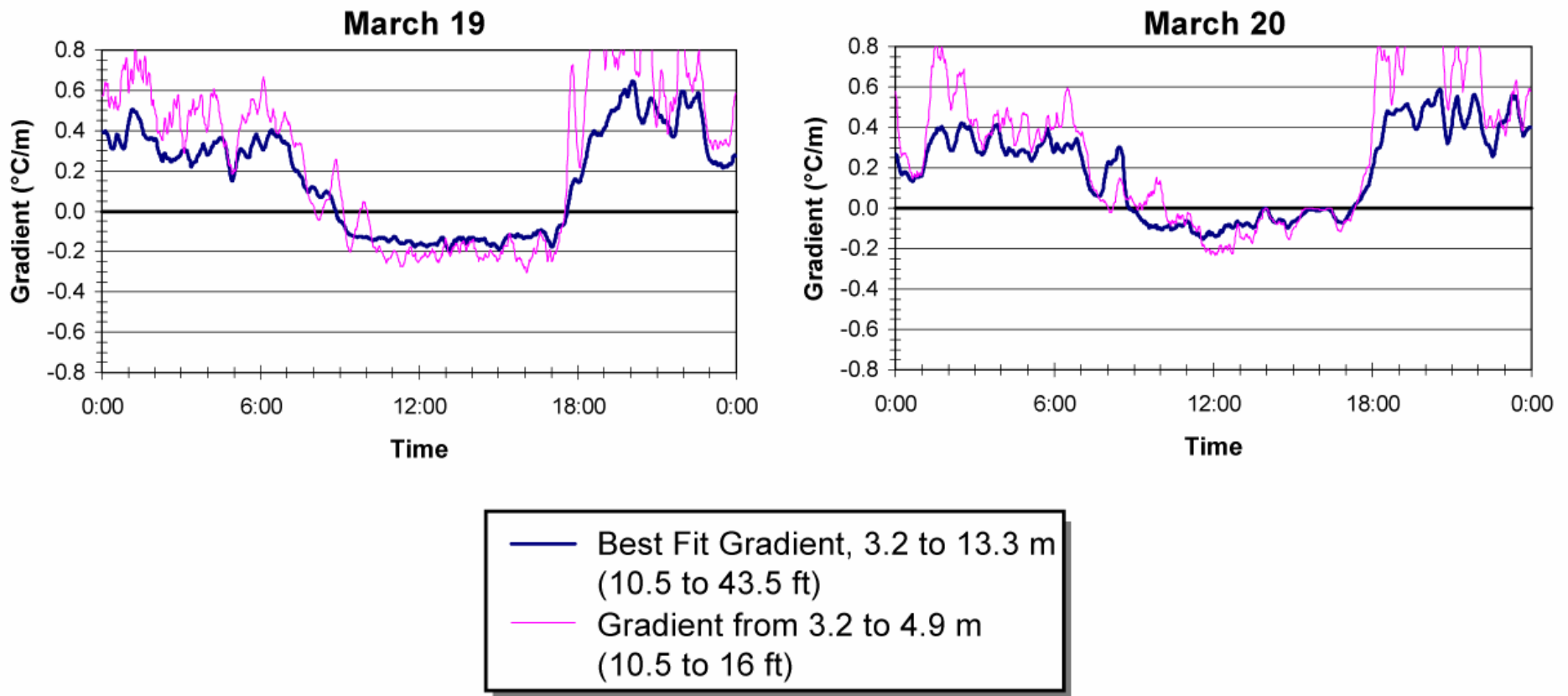
# 1/3 Octave Spectrum Before and After ARFC



# Temperature Gradients, 15-min Moving Average



# Temperature Gradient Best Fit and Two Point



# Conclusions, Effects of Atmospheric Conditions

- Nighttime inversion increases A-weighted sound levels by 5 to 8 dB relative to neutral atmospheric conditions.
- Daytime lapse reduces A-weighted sound levels 5 to 10 dB relative to neutral atmospheric conditions.
- The nighttime down-slope flows cause localized focusing and de-focusing on the order of -10 to +4 dB.
- Down-slope flows can occur without ground-level air flows.
- Sound level variations under inversion conditions appear to be greatest at upwind locations relative to the down-slope flows.
- Locations with consistent nighttime inversion conditions are likely to experience high levels of traffic noise from sunset to sunrise.
- Inversion strength may be straightforward to measure with 2 to 3 thermocouples.

# Conclusions, Asphalt Rubber Friction Course

- Reduced A-weighted sound levels 8 to 10 dB.
- Equally effective at close-in and community locations.
- Sound levels with ARFC were approximately 6 dB lower than TNM predictions
- Improvement was entirely at frequencies greater than 500 Hz.



